Detection Test for Language impairments in Adults and the Aged - A new screening test for language impairment associated with neurodegenerative diseases: Validation and normalization data.

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**Order of Authors Secondary Information:**
Detection Test for Language impairments in Adults and the Aged - A new screening test for language impairment associated with neurodegenerative diseases: Validation and normalization data

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Abstract

Background: Aging is the most important risk factor for cognitive decline, and the detection of cognitive impairment in at-risk middle-aged and elderly individuals has become a societal priority. Early diagnosis of dementia relies on various assessments. Primary care physicians use cognitive screening tests to diagnose dementia. However, this type of assessment is still not extensively performed in standard practice and numerous patients who have dementia remain undiagnosed. To date, there is no quick screening test that could be used during routine office visits to accurately assess language disorders in neurodegenerative diseases. To fill this important gap we developed the Detection Test for Language impairments in Adults and the Aged (DTLA), a quick, sensitive, standardized screening test designed to assess language disorders in adults and the elderly. Methods: In Study 1, we describe the development of the DTLA. This test comprises nine sensitive, easy-to-administer tasks designed to quickly (5 minutes) assess the language domains and abilities most frequently affected in these diseases, with particular attention paid to those with the best discrimination value among clinical syndromes. In Study 2, we report data on the DTLA’s convergent and discriminant validity as well as its internal consistency and test-retest reliability. Finally, in Study 3, we establish normative data for the test. Results: The DTLA has good convergent and discriminant validity as well as good internal consistency and test-retest reliability. Norms for the DTLA obtained from a sample of 545 healthy, community-dwelling, French-speaking adults from four French-speaking countries (Belgium, Canada (Quebec), France and Switzerland) are provided. Conclusions: The development, validation and standardization of the DTLA constitute a significant effort to meet the need for a language-screening test adapted to neurodegenerative diseases.
**Key Words**

Cognitive abilities screening instrument; Dementia; Primary progressive aphasia; Normative data; Validity

**BACKGROUND**

The number of people aged 60 years and over is expected to at least double by 2050, reaching approximately 2 billion older adults worldwide [1]. This dramatic demographic growth has important economic, political, and societal implications. Normal aging is accompanied by changes in cognitive functions. These changes do not occur in a uniform way in all cognitive domains. Most of the cognitive changes observed in normal aging have been attributed to a reduction in processing speed [2]. Due to changes in the nervous system, older people often perform less well than younger adults on tests measuring attention, working memory, episodic memory and executive functions [3]. Compared to these domains, language appears to be mostly resistant to age-related decline in normal aging. Older adults maintain or even improve knowledge of words and word meanings [4]. However, difficulties retrieving spoken and written forms of words usually become more frequent with age [5].

From a public health perspective, the demographic aging trend is accompanied by a tremendous growth in neurodegenerative diseases. The number of individuals with dementia worldwide is estimated to nearly double every 20 years, from 35.6 million in 2010 to 65.7 million in 2030 and 115.4 million in 2050 [6]. Dementia is a decline in cognitive function affecting memory, visuospatial abilities, executive functions, praxis, gnosis, and thinking. Language is also fragile in pathological aging. Individuals diagnosed with mild cognitive impairment, that is, the condition between healthy aging and dementia, often show language deficits affecting word comprehension, word production, syntax and discourse [for a review, see 7]. In dementia, clinical linguistic profiles have been described following neuroepidemiological and neuropsychological
studies. Recent neuropsycholinguistic studies have also made a major contribution to improving the characterization of language deficits in dementia by specifically identifying impaired and preserved processing components of language processing. For instance, in addition to progressive episodic memory loss, people with Alzheimer's disease (AD) usually present with semantic memory impairment leading to word-finding and word comprehension deficits. With respect to written language, studies in AD also reveal the presence of surface dyslexia and surface agraphia, although different patterns of written language impairment may also be observed [for a review, see 8]. Language is also affected in the early stages of other major forms of dementia, including vascular dementia and Lewy body dementia. For example, compared to AD, the spontaneous speech of individuals with vascular dementia is less empty and conveys more information but they tend to produce shorter and less grammatically complex phrases [9]. A further example is the presence of syntactic impairment in sentence comprehension in individuals with Lewy body dementia, a deficit attributed to working memory and executive dysfunctions [10]. Finally, language deficits are at the core of the clinical portrait of primary progressive aphasia (PPA). PPA is a progressive language disorder associated with atrophy of the frontal and temporal regions, typically resulting from a neurodegenerative disease. PPA is a heterogeneous condition, in which the most prominent clinical feature is difficulty with language (progressive impairment of language production, syntax, or word comprehension), while other cognitive domains, including memory, visuospatial skills, and executive abilities, are not affected at the onset and in the early stages of the disease [11]. A broad-ranging International Consensus Group recently published recommendations for the diagnosis and classification of PPA [12]. These recommendations provide a classification of PPA and its three main variants, namely the nonfluent/agrammatic variant (nfvPPA), semantic variant (svPPA), and logopenic variant (lvPPA). According to this classification, the following core features must be identified to detect
each of the PPA variants: a) apraxia of speech and agrammatism in language production for
nfvPPA; b) impaired confrontation naming and impaired single-word comprehension for svPPA;
and c) anomia in spontaneous speech and confrontation naming, and impaired repetition of long
sentences for lvPPA. There are also some supporting features and specific imaging abnormalities
[12].

Early diagnosis of dementia relies on various types of assessment performed to detect the
disease (screening) or rule out other possible causes of cognitive impairment (i.e., differential
diagnosis). With respect to cognition and language, the main goal of screening is to determine
whether a patient has a problem or not. The output of this type of assessment is a ‘pass’ or ‘fail’
result, based on an established criterion that could lead to a more exhaustive or follow-up
assessment. Cognitive screening tests are used by primary care physicians to diagnose dementia.
However, this type of assessment is still not extensively done in standard practice and numerous
patients who have dementia remain undiagnosed [13]. When faced with complex clinical
presentations such as primary language symptoms, physicians refer patients to specialists, such as
geriatricians or neurologists, who also commonly use cognitive screening tests such as the Mini-
Mental State Examination [MMSE; 14], Montreal Cognitive Assessment [MoCA; 15] or
Alzheimer’s Disease Assessment Scale-Cognitive Subscale [ADAS-Cog; 16]. In the majority of
these screening tests, the focus of the assessment is memory dysfunction, the hallmark of AD,
whilst impairments in other cognitive domains such as praxis, executive functions and language
are largely underestimated. However, according to the fifth edition of the Diagnostic and
Statistical Manual of Mental Disorders [17], neurocognitive dysfunction in adults is not limited to
learning and memory problems but also includes difficulties with complex attention, executive
functions, perceptual and motor abilities, social cognition and language. Moreover, studies have
shown that screening tests for dementia could be misleading when used with patients with language problems [e.g., 18].

Even though most cognitive screening tests involve subtests of language function, these are often limited to naming (e.g., MoCA) or verbal fluency (MoCA, MMSE, etc.), a task mainly relying on executive functions. As an exception, a large part of Addenbrooke's Cognitive Examination [ACE; 19] and its revised version [ACE-R; 20] is devoted to assessing language, with subtests covering not only picture naming and verbal fluency but also language comprehension, semantic matching, repetition, reading and spelling. The ACE-R has proven to be effective in detecting and tracking the evolution of neurodegenerative diseases in which the core symptoms are language-related, such as nfvPPA and svPPA [21]. However, considering the clinical presentation of PPA variants, some language subdomains are missing from the ACE-R: syntactic comprehension (affected in nfvPPA), and reading and spelling of pseudowords (preserved in svPPA). Additionally, the ACE-R includes a sentence repetition subtest but stimuli are limited to two short syntactically complex sentences, while one of the most distinctive features of lvPPA is impairment in the repetition of long sentences because of short-term memory deficits. Finally, the average administration time for this test is around 16 minutes [20], which is lengthy for primary care clinicians. There are some screening tests for language impairment such as the Frenchay Aphasia Screening Test [22] and Mississippi Aphasia Screening test [23] but they were developed for aphasia and are not suitable for language deficits associated with neurodegenerative diseases.

As a result, primary care providers are frequently faced with patients whose main complaints concern language problems in everyday and professional life. To date, however, there is no quick screening test that could be applied during routine office visits to accurately assess language disorders in neurodegenerative diseases. Such a test would improve referrals to
specialized resources (memory clinic, geriatrics, neurology, speech-language pathology, neuropsychology), where the diagnosis could be confirmed and the appropriate health care provided. Also, the use of such a test would improve the diagnosis of neurodegenerative diseases, especially those in which language is primarily affected. Ultimately, this will permit patients and their families to receive services at an earlier stage of the disease.

To fill this important gap, we developed a quick, sensitive, standardized French screening test designed to assess language disorders in adults and the elderly. In this article we first describe the development of the "Dépistage des troubles du langage chez l'adulte et la personne âgée" (DTLA - Detection Test for Language impairments in Adults and the Aged), a new screening test developed in four French-speaking countries (Belgium, Canada (Quebec), France and Switzerland). We also studied the validity and reliability of the test and established normative data from a representative sample of adults and elderly participants. Thus, three studies are presented in this paper. In Study 1, we describe the design and development of the DTLA. In Study 2, we report data on the convergent and discriminant validity of the DTLA as well as on its test-retest reliability and internal consistency. Finally, in Study 3, we provide normative data for healthy, community-dwelling, French-speaking people from the four French-speaking countries.

STUDY 1. DEVELOPMENT OF THE DTLA

Methods

We followed a comprehensive test development approach, including the establishment of translational validity. Translational validity refers to the transformational aspect of construct validity and includes content and face validity [24]. The content validity of the DTLA was established on the basis of the scientific literature. The research team first identified the language domains and abilities most frequently affected in neurodegenerative diseases, with special
attention paid to those with the best discrimination value among clinical syndromes. Next, the most sensitive and easy-to-use assessment tasks were selected for each domain of interest. The research team then determined the number of items as well as their psycholinguistic characteristics in each assessment subtest, with the objective of developing a short test, which could be administered in approximately five minutes.

The following language assessment tasks were selected for the screening test: 1) picture naming; 2) word, nonword and sentence repetition; 3) verbal fluency; 4) spelling to dictation of words and nonwords; 5) spontaneous written sentence production; 6) reading aloud of words and nonwords; 7) sentence-to-picture matching; 8) written word matching; and 9) alpha-span. Lexical access is consistently affected in almost all neurodegenerative diseases. Deficits in this domain lead to substantial difficulties in confrontation naming, which is why a spoken picture-naming task was chosen. A phonemic verbal fluency task was also selected to assess lexical access. This task requires the generation of a lexical strategy, sustained by executive functions, which guides the search for words in the mental lexicon. Impairment in phonemic verbal fluency has been consistently reported in the majority of neurodegenerative diseases, including the three PPA variants [25, 26]. Performance on sentence repetition tasks is essential to differentiate lvPPA from the two other PPA variants. Moreover, apraxia of speech, which is one of the two core features of nfvPPA, could be exacerbated in nonword and sentence repetition tasks, and help to differentiate individuals with nfvPPA presenting with apraxia of speech from those with agrammatism [27]. A word, nonword and sentence repetition task was therefore selected. Impairment of written production abilities usually occurs very early in the course of the majority of neurodegenerative diseases [for a review, see 8]. For example, individuals with AD [28] or svPPA [29] often develop surface dysgraphia. Dysgraphia involves written agrammatism and the production of non-phonologically plausible paragraphias in nfvPPA [30], while patients with
lvPPA usually present with phonological dysgraphia [31]. Spontaneous writing may also be affected in neurodegenerative diseases [e.g., 32, 33]. Impairment in this task usually mimics the manifestations observed in spoken production (i.e. difficulties in lexical access, inflectional morphology, syntactic structure). A task involving spelling to dictation of words and nonwords as well as a spontaneous written sentence production task were selected to assess written production abilities. Reading difficulties are key features in AD and PPAs. They are observed in AD and svPPA in the form of surface dyslexia. In nfvPPA, disease progression is sometimes accompanied by the production of phonological errors in reading [27], while a pattern of phonological dyslexia is observed in lvPPA [34]. A word and nonword reading aloud task was chosen to assess reading. Sentence comprehension is another domain that can be compromised in neurodegenerative diseases. Deficits in this domain have been reported in cases of AD [35] and Lewy body dementia [10], even in the early stages of the disease. The impaired comprehension of syntactically complex sentences is one of the three additional features that must be present to detect nfvPPA [12]. Moreover, impairment in sentence comprehension was also found in lvPPA patients [36] due to a reduction in verbal short-term memory resources. A sentence-to-picture matching task was chosen to assess sentence comprehension. Also, semantic processing is consistently affected in AD [37]. Semantic impairment is also at the core of the clinical manifestations of svPPA [12], while semantic processing is preserved in the other two PPA variants. A semantic written word matching task was selected to assess semantic processing. Finally, some of the language deficits observed in neurodegenerative diseases are caused by phonological short-term memory and/or verbal working memory impairments. Such an origin was posited to explain difficulties in sentence production and sentence comprehension observed in AD [35] and Lewy body dementia [10]. Reduction in phonological short-term memory resources was also proposed to account for the deficit in sentence repetition [12] and sentence
comprehension in lvPPA [36]. An alphabetization span task (“alpha-span task”), which requires subjects to recall presented words in alphabetical order, was selected to assess phonological short-term/working memory. The cognitive domains, tasks and characteristics of the items chosen as a result of the development process are presented in Table 1.

Table 1. Cognitive domains, tasks and item characteristics (number of stimuli) of the DTLA

<table>
<thead>
<tr>
<th>Cognitive domain</th>
<th>Task</th>
<th>Item characteristics (number of stimuli)</th>
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<tbody>
<tr>
<td>Lexical access in production</td>
<td>Picture naming</td>
<td>□ Biological concepts (3) □ Man-made concepts (3)</td>
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<tr>
<td>Spoken production and phonological short-term</td>
<td>Repetition</td>
<td>□ Phonologically complex 3-syllable words (3) □ 3-syllable nonwords (3) □ Long sentences at least 15 syllables in length (3)</td>
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<tr>
<td>memory</td>
<td></td>
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<tr>
<td>Spoken production and executive functions</td>
<td>Verbal fluency</td>
<td>□ Phonemic verbal fluency with letter D in 1 min.</td>
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<tr>
<td>Written production</td>
<td>Spelling to dictation</td>
<td>□ Irregular words (3) □ Nonwords (3) □ Written sentence spontaneous production</td>
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<tr>
<td></td>
<td>Spontaneous writing</td>
<td></td>
</tr>
<tr>
<td>Lexical and nonlexical reading</td>
<td>Reading aloud</td>
<td>□ Irregular words (3) □ Nonwords (3)</td>
</tr>
<tr>
<td>Syntactic comprehension</td>
<td>Sentence-to-picture matching</td>
<td>□ Cleft object sentence (1) □ Agentless passive sentence (1) □ Passive sentence with agent (1)</td>
</tr>
<tr>
<td>Semantic memory</td>
<td>Written word matching</td>
<td>□ Word triplets corresponding to biological concepts (2) □ Word triplets corresponding to man-made concepts (2)</td>
</tr>
<tr>
<td>Verbal working memory</td>
<td>Alpha-span</td>
<td>□ One-syllable word triplet (1)</td>
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Once the tasks and items were chosen, a pilot study was conducted to develop the final version of the DTLA. A screening test with four times as many stimuli as required for the final version of the test was created (except for verbal fluency, spontaneous writing and alpha-span: 2 three-item lists, 1 four-item list and 1 five-item list). This preliminary version also comprised the
administration protocol for each subtest including the language domain assessed, the stimuli, the psycholinguistic variables controlled and manipulated, and the instructions. Clinical experts then reviewed this version to establish the instrument’s face validity. A total of 18 professionals in the four countries (1 geriatrician, 2 neurologists, 7 neuropsychologists, 1 psychiatrist, and 7 speech-language pathologists) were invited to review the preliminary version of the DTLA by means of a questionnaire specifically developed to evaluate its appropriateness, usefulness, ease-of-use and clarity (administration sheet, instructions). All informants agreed wholeheartedly with the purpose and usefulness of the instrument. After their review, adjustments were made to all the elements where a lack of clarity was identified. Following these adjustments, the preliminary version of the DTLA was administered to 106 healthy participants (normal age- and education-adjusted MMSE scores) in the four French-speaking countries (Belgium = 40, France = 25, Canada = 23, Switzerland = 18) in order to proceed to the final selection of stimuli. The mean age of these participants was 65.2 years (SD = 9.5, range = 50-88), their mean level of education was 12.56 years (SD = 3.34, range = 6-23), and the gender distribution was 37 males and 69 females. For the final selection of stimuli, the items kept were those for which the best scores were obtained in the four countries. The average success rates for each task were: picture naming = 99.83% (SD = .41); repetition: words = 100%, nonwords = 95% (SD = 3.61), sentences = 87% (SD = 6.24); spelling to dictation: words = 91.33% (SD = 3.39), nonwords = 96.67% (SD = 3.2); reading aloud: words and nonwords = 100%; sentence-to-picture matching = 100%; written word matching = 100%. On average, the participants produced 12.31 (SD = 1.35) words beginning with the letter D in the fluency task. In 96.33% (SD = 3.51) of them, the spontaneous production of a sentence was correct. Finally, for the alpha-span, the average success rates were low for the four-item (47%, SD = 10.47) and five-item (11%, SD = 3.7) lists, so the three-item list was retained (95%, SD = 5.97).
The final version of DTLA is presented on a single double-sided sheet held in portrait orientation. The five of the six pictures in the naming task were taken from Snodgrass and Vanderwart [38] and one was taken from Bonin et al. [39], while the picture for the sentence-to-picture matching task is original artwork.

The scoring method was established according to the relative value of each subtest for the detection of language impairment for a total maximum score of 100 points. We chose to use a 100-point scale for two reasons. First, its use and interpretation is more intuitive (i.e., people are used to considering 100 points a perfect score). Second, it enabled us to better distribute the relative weight of each subtest in the total score by avoiding the use of decimals. Two points are given for each of the six pictures in the picture naming subtest, for a total of 12 points. Two points are given for each of the 9 items in the repetition subtest, for a total of 18 points. Fifteen points are given for the verbal fluency subtest, according to the following cutoff scores for two education levels, calculated on the basis of data collected in the normative study (see below): production of 8 words for individuals who have 11 or fewer years of formal education and production of 10 words for individuals with 12 or more years of formal education. Two points are given for each of the 6 items in the spelling to dictation subtest, for a total of 12 points. Four points are given for the production of a sentence with a simple subject-verb-complement structure in the spontaneous writing subtest. One point is given for each of the 6 items in the reading aloud subtest, for a total of 6 points. Four points are given for each of the 3 items in the sentence-to-picture matching subtest, for a total of 12. Four points are given for each of the 4 items in the written word matching, for a total of 16 points. Finally, 5 points are awarded for the correct repetition of the one-syllable word triplet in the alpha-span subtest. The DTLA protocol, administration procedure and instructions are available upon request from the first author.
STUDY 2. VALIDITY AND RELIABILITY OF THE DTLA

The purpose of Study 2 was to provide data on the DTLA’s convergent and discriminant validity as well as on its test-retest reliability and internal consistency. The DTLA was designed to assess language impairment in neurodegenerative diseases. However, it is conceivable that it could also be used to detect language deficits in other neurological populations. Therefore, convergent validity, discriminant validity and internal consistency were established by including participants presenting with neurodegenerative diseases and participants with post-stroke aphasia. The study was approved by local Research Ethics Boards and all participants gave their written informed consent to participate. A schematic representation of the DTLA validation process is presented in Figure 1.

[Insert Figure 1 about here]

Methods

Participants, materials and procedure

Convergent validity. Thirty-one patients were recruited. Twenty patients had a diagnosis of probable AD (mean age = 77.75, SD = 7.85 years; mean education = 13, SD = 3 years; mean MMSE score = 21.10, SD = 4.15), 7 patients had post-stroke aphasia (mean age = 66.29, SD = 9.25 years; mean education = 13, SD = 3.26 years; mean MMSE score = 21.29, SD = 4.35), and 4 patients had a diagnosis of primary progressive aphasia (mean age = 76, SD = 7 years; mean education = 9, SD = 3.47 years; mean MMSE score = 23, SD = 3). The following tests were administered to all the participants: the DTLA, Boston Naming Test [40]; repetition, comprehension, reading, spelling and written questionnaire subtests of the Protocole Montréal-Toulouse d'examen linguistique de l'aphasie MT-86 [41]; fluency subtest of the Protocole
Montréal d’Évaluation de la Communication MEC [42]; digit span subtest of the Wechsler Memory Scale - Fourth Edition [43]; and Pyramids and Palm Trees Test [44].

**Discriminant validity.** We tested whether the DTLA score distinguished between the performances of controls and patients with AD and between the performances of controls and patients with post-stroke aphasia. To do so, two groups were compared: 1) a group of 12 patients with a diagnosis of probable AD, matched to a group of 24 healthy control participants by age (AD: mean age = 74.5, SD = 4.83 years; Controls: mean age = 73.5, SD = 5.24 years; \( t(34) = -0.553, \ p = .58 \)) and education (AD: mean education = 13.58, SD = 3.06 years; Controls: mean education = 13.71, SD = 3.71 years; \( t(34) = .101, \ p = .92 \)); and 2) a group of 12 patients with post-stroke aphasia, matched to a group of 24 healthy control participants by age (aphasia: mean age = 62.67, SD = 6.44 years; Controls: mean age = 64.33, SD = 5.80 years; \( t(34) = .784, \ p = .44 \)) and education (aphasia: mean education = 12.08, SD = 2.87 years; Controls: mean education = 12.08, SD = 3.84 years; \( t(34) < .001, \ p = .1 \)). Both groups of patients differed significantly from controls in terms of their score on the MMSE (AD: mean score = 21.42, SD = 3.73; Controls: mean score = 28.42, SD = 1.35; \( t(34) = 8.27, \ p < .001 \); Aphasia: mean score = 24.25, SD = 4.58; Controls: mean score = 28.42, SD = 1.18; \( t(34) = 4.24, \ p < .001 \)).

**Test-retest reliability.** The DTLA was administered twice to twenty healthy participants (mean age at first testing = 62.4, SD = 6.73 years; mean education = 12.7, SD = 2.87 years; mean MMSE score = 28.55, SD = 1.73) with a 6-month interval.

**Internal consistency.** This type of reliability was studied with a sample of 602 participants divided into four groups: 1) healthy controls (n = 561; mean age = 63.96, SD = 9.21 years; mean education = 12.5, SD = 3.39 years; mean MMSE score = 28.53, SD = 1.30); 2) patients with AD (n = 20; mean age = 77.75, SD = 7.85 years; mean education = 13.15, SD = 3.07 years; mean MMSE score = 21.10, SD = 4.15); 3) patients with post-stroke aphasia (n = 17; mean age =
68.06, SD = 10.86 years; mean education = 11, SD = 3.20 years; mean MMSE score = 22.71, SD = 6.14); and 4) patients with primary progressive aphasia (n = 4; mean age = 76, SD = 7.07 years; mean education = 9, SD = 3.46 years; mean MMSE score = 23, SD = 3).

Results

Convergent validity

Table 2 shows the correlation matrix between the external measures and DTLA subtests. The relevant correlations are highlighted in gray. As expected, the external measures that assessed the same construct correlated significantly and positively with the corresponding DTLA subtests, except for two of them. First, the Pyramids and Palm Trees Test [44] did not correlate significantly with the written word matching subtest of the DTLA, even though both tests focus on semantic processing. However, the Boston Naming Test [40], which also includes semantic processing, and the written word matching DTLA subtest correlated positively and significantly. Second, the digit span subtest of the Wechsler Memory Scale - Fourth Edition [43] and the alpha-span subtest of the DTLA, both measures of working memory, failed to show a significant correlation.

[Insert Table 2 about here]

Discriminant validity

The mean DTLA score of patients with AD patients was significantly lower than that of healthy controls (AD: mean score = 81.75, SD = 15.51; Controls: mean score = 95.17, SD = 5.78; t (34) = 4.43, p < .001). Also, the mean DTLA score of patients with post-stroke aphasia was significantly
lower than that of healthy controls (Aphasia: mean score = 58.83, SD = 15.46; Controls: mean score = 93.79, SD = 8.20; t (34) = 8.92, p < .001).

**Test-retest reliability**

The performance of healthy controls on the DTLA did not differ between the first (T1) and second testing (T2), conducted 6 months after the first (T1 mean score = 94.10, SD = 7.36; T2 mean score = 96.20, SD = 5.56; t (19) = -1.63, p = .12).

**Internal consistency**

The Cronbach’s alpha coefficient obtained was .84 for the 36 elements that make up the DTLA’s stimuli (except for fluency since it does not have values of 0 or 1 but is composed of the number of words produced by participants). According to Cortina [45], a coefficient between .8 and .9, like the one we found, is considered to indicate good internal consistency.

**Summary**

From the analyses carried out, we can conclude that, overall, the DTLA has good convergent validity. The screening test can also distinguish between the performance of controls and patients with AD and controls and patients with post-stroke aphasia and therefore presents good discriminant validity. The stability of the DTLA over time is good (test-retest reliability) as is its internal consistency.

**STUDY 3. NORMATIVE DATA**

The purpose of Study 3 was to provide normative data for the DTLA, adapted to adult and aged populations from the four French-speaking countries.

**Method**

**Participants**
A total of 545 healthy, community-dwelling, French-speaking adults, whose mother tongue and currently used language was French, were recruited in the four French-speaking countries (Belgium: \( n = 76, 13.09\% \); Quebec, Canada: \( n = 99, 18.2\% \); France: \( n = 255, 46.8\% \); Switzerland: \( n = 115, 21.1\% \)). All participants had normal age- and education-adjusted MMSE scores (MMSE \( \geq 26 \); mean score = 28.54, SD = 1.3) [14], indicating normal cognition. All participants self-reported good mental and physical health (i.e., no history of neurological disease, current untreated psychiatric illness, traumatic brain injury, or untreated medical condition that could interfere with cognitive performance).

The sample was composed of 235 men (43\%) and 310 women (57\%), aged between 50 and 80 (mean age = 63.32 years, SD = 8.53 years), with an education level varying between 2 and 26 years (mean education = 12.5 years, SD = 3.37 years). Based on the education systems of the four countries and in previous experiences with tests for French-speaking populations [see, for instance, 42], participants were recruited by speech-language pathology students through public advertisements and among relatives to form four mutually exclusive age and education groups: 1) 50 to 64 years of age and 11 or fewer years of formal education, 2) 50 to 64 years of age and 12 or more years of formal education, 3) 65 to 80 years of age and 11 or fewer years of formal education, and 4) 65 to 80 years of age and 12 or more years of formal education. The study was approved by local Research Ethics Boards and all participants gave their written informed consent to participate in the study. Table 3 shows the descriptive statistics of the four groups of participants for the normative study as a function of age and education.
Table 3. Descriptive statistics (mean and standard deviation) of the four groups of participants for the normative study as a function of age (≥ 65 and 65+ years) and education (≥ 11 and 12+ years)

<table>
<thead>
<tr>
<th></th>
<th>50-64 years</th>
<th></th>
<th>Age</th>
<th>65-80 years</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥ 11 years</td>
<td>12+ years</td>
<td>≥ 11 years</td>
<td>12+ years</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Age</td>
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<td>4.42</td>
<td>55.93</td>
<td>3.95</td>
<td>71.74</td>
</tr>
<tr>
<td>Education</td>
<td>9.86</td>
<td>1.77</td>
<td>14.81</td>
<td>2.42</td>
<td>9.40</td>
</tr>
<tr>
<td>% Women</td>
<td>59</td>
<td>54</td>
<td>63</td>
<td>63</td>
<td>53</td>
</tr>
<tr>
<td>N</td>
<td>126</td>
<td>166</td>
<td>124</td>
<td>129</td>
<td></td>
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<tr>
<td>DTLA</td>
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<td>97.73</td>
<td>4.19</td>
<td>91.58</td>
</tr>
<tr>
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<td>94</td>
<td>93</td>
<td>92</td>
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<tr>
<td>Cutoff</td>
<td>78</td>
<td>85</td>
<td>75</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Total N</td>
<td>545</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: SD = standard deviation; Age: age in years; Education: formal education in years; Women: percentage of women; N: number of participants in the group; DTLA: Detection Test for Language impairments in Adults and Aged people score /100; Alert: suggested alert score calculated as the 15th percentile (score below it and above the cutoff may indicate “at risk”); Cutoff: suggested cutoff score calculated as the 5th percentile (score equal to or below it is under normal performance limits); Total N: total number of participants in the normative study.

Materials and procedure

All participants were tested individually in a quiet room at their home or a research center. Tasks were administered without any time constraints. All of the DTLA’s visual stimuli (pictures, written words) were presented on the test sheet. Written protocols for the tests were collected by research assistants and data were entered in the analyses.

Results

Two-way analyses of variance ANOVA were carried out with age (≥ 65 and 65+ years) and education (≥ 11 and 12+ years) as between-subject factors and the total score on the DTLA (max 100 points) as the dependent variable. Results showed that age, F (1, 541) = 11.28, p < .01, η² = .020, and education, F (1, 541) = 61.84, p < .001, η² = .10, significantly affected performance on the DTLA. The interaction of age x education did not reach significance, with F (1, 541) = .70, p = .40.
We calculated the 5th, 15th, 25th and 50th percentiles for the DTLA score for each group. After visual exploration of the whisker plots and according to the usual criteria [46], we chose the 5th percentile as the most reliable cutoff score. A score equal to or below the suggested cutoff score can be considered to be under normal performance limits. We also proposed an alert score based on the 15th percentile. A score below this alert score is not necessarily, but might be, under normal performance limits. Further testing is suggested in such cases. Table 3 shows the suggested cutoff and alert scores for each group of participants. The average time to complete the DTLA is about 5 minutes.

DISCUSSION

Aging is the most important risk factor for cognitive decline, and the detection of cognitive impairment in at-risk middle-aged and elderly individuals has become a societal priority. In frontline services as well as specialized clinics, this detection is done by means of cognitive screening tests such as the MMSE [14] or MoCA [15]. In the majority of these tests, the assessment focuses on memory dysfunction, the hallmark of AD, whilst other cognitive domains such as praxis, executive functions and language are largely ignored. Furthermore, studies have shown that screening tests for dementia could be misleading when used with patients with language problems [e.g., 18]. Language deficits are an integral part of clinical symptoms in all the major forms of neurodegenerative diseases. They are also the core features of the three variants of primary progressive aphasia. Most cognitive screening tests involve subtests of language function (e.g., picture naming in MoCA, verbal fluency in MoCA and MMSE). However, these tests are not sensitive enough to capture the entire spectrum of language manifestations in dementia or they are too time-consuming to administer (e.g., [ACE-R; 20]) for them to be used in primary care services. In short, there is no quick, sensitive screening test that
could be administered during routine office visits to assess language deficits in neurodegenerative diseases.

The DTLA was explicitly developed to meet the need for an assessment tool specifically addressing the language impairment encountered in the majority of neurodegenerative diseases. This test comprises nine sensitive, easy-to-administer tasks designed to quickly (5 minutes) assess the language domains and abilities most frequently affected in these diseases, with particular attention paid to those with the best discrimination value among clinical syndromes. The results of the psychometric study of this new tool showed that it has good convergent and discriminant validity as well as very good internal consistency and test-retest reliability. This study also provides norms for the DTLA obtained from a sample of 545 healthy, community-dwelling, French-speaking adults. These individuals, aged between 50 and 80 years, with an education level varying between 2 and 26 years, were recruited in four French-speaking countries (Belgium, Canada (Quebec), France and Switzerland). The development, validation and standardization of such a screening instrument constitute a significant effort to meet the need for a language screening test adapted to neurodegenerative diseases.

As a screening test, the main goal of the DTLA is to determine whether an individual has language impairment. Although scores on specific subtests can provide information concerning the possible etiology of deficits, the tests were not designed to make differential diagnoses. The suggested cutoff and alert scores provided in this study for the DTLA should be used respectively to confirm the presence of a language impairment or to raise a flag and prompt further and more extensive language assessment. Other information collected during the medical visit may supplement the DTLA results, for example, specific complaints about language, word-finding, articulatory or syntactic problems apparent during the interview, etc.
The large group of participants is a major strength of this normative study. Despite this significant number, however, further studies are needed to, for example, extend the DTLA normative data to include people aged 81 and over. Another limitation of the present study was the use of an incidental sampling method, which could have resulted in selection bias. Although a random sampling method would have been preferable, this study is a practical and relevant starting point for establishing DTLA norms for the French-speaking population.

Culture has an impact on cognition and therefore it is important to use normative data specific to the population to which they are applied. This is particularly true for the assessment of language functions, considering the possible psycholinguistic (e.g., vocabulary, familiarity of concepts) biases. The DTLA was created by selecting stimuli culturally adapted to the populations in the four French-speaking countries. Further studies are now necessary to develop DTLA versions in other languages.

CONCLUSIONS

To conclude, this study provides psychometric and normative data for the DTLA, a new screening test for the quick assessment of language abilities in adults and elderly people. These norms, established from a wide sample of individuals selected from the community in four French-speaking countries, will be useful to primary care and specialized clinicians in detecting language impairments associated with neurodegenerative diseases.

ABBREVIATIONS

DTLA: Detection Test for Language impairments in Adults and the Aged
AD: Alzheimer's disease
PPA: primary progressive aphasia
nfvPPA: nonfluent/agrammatic variant
svPPA: semantic variant
 lvPPA: logopenic variant
MMSE: Mini Mental State Examination
MoCA: Montreal Cognitive Assessment
ADAS-Cog: Alzheimer’s Disease Assessment Scale-Cognitive Subscale
ACE: Addenbrooke's Cognitive Examination
ACE-R: Addenbrooke's Cognitive Examination-Revised

DECLARATIONS

Ethics approval and consent to participate
The study was approved by local Research Ethics Boards and all participants gave their written informed consent to participate.

Consent for publication
Not applicable.

Availability of data and material
The datasets generated and/or analyzed during the present study are not publicly available, owing to patient privacy and ethical issues, but they are available from the corresponding author upon reasonable request.

The DTLA protocol, administration procedure and instructions are available upon request from the first author.

Competing interest
The authors declare that they have no competing interests.

Funding
Not applicable

Authors' contributions
JM was responsible for the coordination of all aspects of the study. All the authors contributed to the study design. JM was responsible for the recruitment of participants in Canada. MF was responsible for the recruitment of participants in Switzerland. TMT and AR were responsible for the recruitment of participants in France. LF was responsible for the recruitment of participants in Belgium. JM and MW analyzed and interpreted the data. All authors reviewed and gave final approval of the manuscript.

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Not applicable.

**Authors' information**

Not applicable

The authors declare no potential conflicts of interest regarding the research, authorship and publication of this article.
References

Table 2. Correlations between external measures and DTLA subtests for convergent validity

<table>
<thead>
<tr>
<th>DTLA subtests</th>
<th>Boston Naming Test</th>
<th>Repetition (MT-86)</th>
<th>Fluency (MEC)</th>
<th>Span task (WMS-IV)</th>
<th>Reading (MT-86)</th>
<th>Comprehension (MT-86)</th>
<th>Spelling to dictation (MT-86)</th>
<th>Written questionnaire (MT-86)</th>
<th>PPTT</th>
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<tr>
<td>Picture Naming</td>
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<td>-.102</td>
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<td>.319</td>
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<td>.307</td>
<td>.487**</td>
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<td>.476**</td>
<td>.605**</td>
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<td>.707**</td>
<td>.691**</td>
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<td>.215</td>
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<tr>
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<td>.546**</td>
<td>.413*</td>
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<td>.486**</td>
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<td>.846**</td>
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<td>.802**</td>
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<td>.206</td>
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<td>.213</td>
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<td>.378*</td>
<td>.147</td>
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<td>.464**</td>
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<tr>
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<td>.442*</td>
<td>.608**</td>
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<td>.734**</td>
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<td>.044</td>
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<td>Spontaneous sentence production</td>
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<td>.613**</td>
<td>.311</td>
<td>.389*</td>
<td>.482**</td>
<td>.412*</td>
<td>.510**</td>
<td>.135</td>
</tr>
<tr>
<td>Written word matching</td>
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<td>-.161</td>
<td>.081</td>
<td>-.012</td>
<td>-.013</td>
<td>.138</td>
<td>.258</td>
<td>0.301</td>
</tr>
</tbody>
</table>

Relevant correlations are highlighted in gray

*p < .05, **p < .01
Figure caption

Title

Figure 1. Schematic representation of the DTLA validation process

Legend

AD: Alzheimer's disease; PPA: primary progressive aphasia; HC: healthy control;
BNT: Boston Naming Test; MT-86: Protocole Montréal-Toulouse d'examen linguistique de
l'aphasie; MEC: Protocole Montréal d'Évaluation de la Communication; WMS: Wechsler
Memory Scale; PTTT: Pyramids and Palm Trees Test
Convergent validity
- 20 probable AD
- 7 post-stroke aphasia
- 4 PPA

Discriminant validity
- 12 probable AD – 24 HC
- 12 post-stroke aphasia – 24 HC

Test-retest reliability
- 20 HC

Internal consistency
- 561 HC
- 20 probable AD
- 17 post-stroke aphasia
- 4 PPA

DTLA
BNT
5 subtests of MT-86
1 subtest of MEC
Digit span subtests of WMS
PPTT

DTLA

DTLA x 2 (6-month interval)

DTLA